RFID Performance Characteristics

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About RFID Alliance Lab

- Provide useful, timely, credible, and unbiased data to end users of RFID products
- Constituents
  - University of Kansas / ITTC
    - Primary research contributor
  - RFID Journal
    - Initial funding, distributor, advertisement
  - Rush Tracking Systems
    - Initiator, subject expert, industry lesion
- Business model
  - Sell reports (~$1,000 / report) to finance future reports
  - Exploring alternative revenue

Why us, why now?

- RFID Revolution is under way
- Need to separate facts from hype
  - What you read ≠ what you get
  - E.g., “commercially available” used very liberally
  - Problems / issues not exposed, little or no data
- Team
  - University credibility, diligence, approach
  - Industry involvement focuses on relevant, pressing problems
  - RFID Journal as publication platform to disseminate results

Performance Metrics

- Performance, not conformance

- Orientation sensitivity
- Tags near metal, water
- Read distance
- Variance in performance
- Conveyors

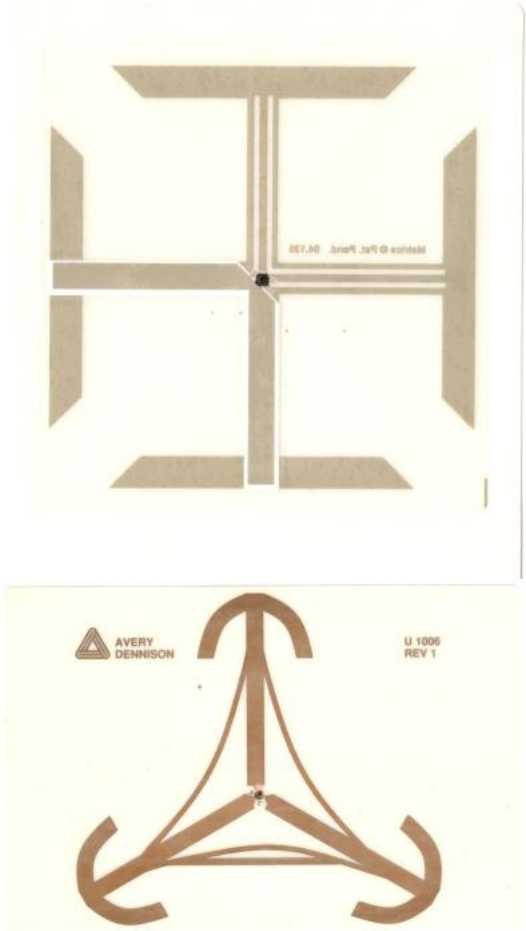
First Report

- Radiation Pattern (orientation sensitivity)
- Read Distance, typical
- Tags near metal
- Tags near water
- Conveyor testing

Tags Analyzed

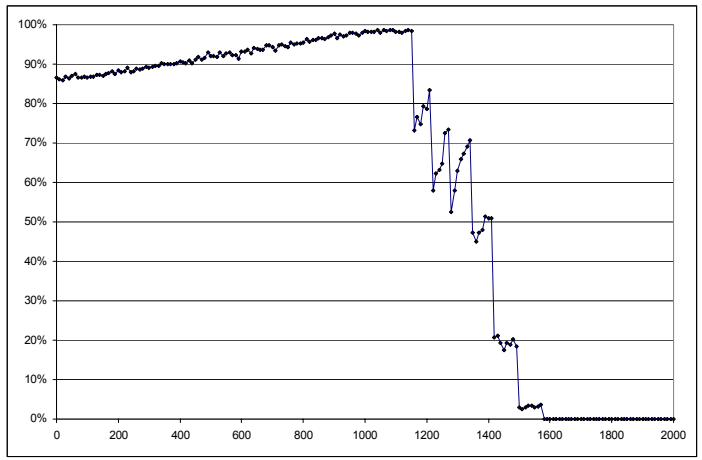
Tags:

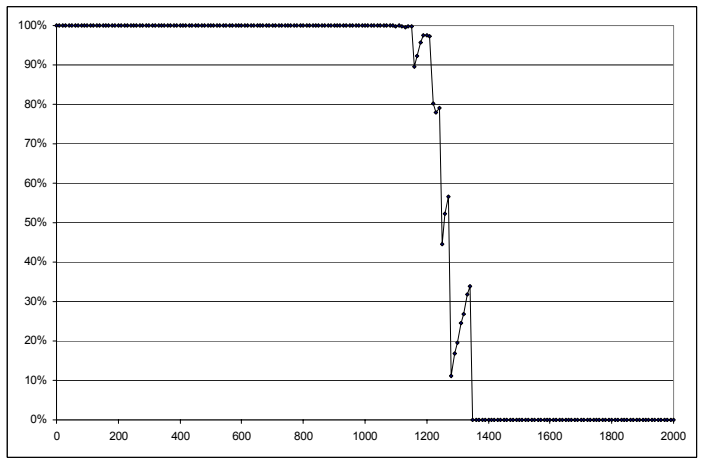
- Matrics X2040
- Avery Triflex
- Rafsec 457
- Rafsec 458
- Alien 9250
- Alien 9338
- Alien 9254
- Avery U1014
- Matrics I2010
- Avery DS1



Typical Tag Performance vs. Distance

- How do you measure performance?
  - Successful reads / attempted reads
  - ThingMagic Mercury 4 reader
- 2 typical Class 1 tags
  - 5000 reads / power setting
  - 200 power settings



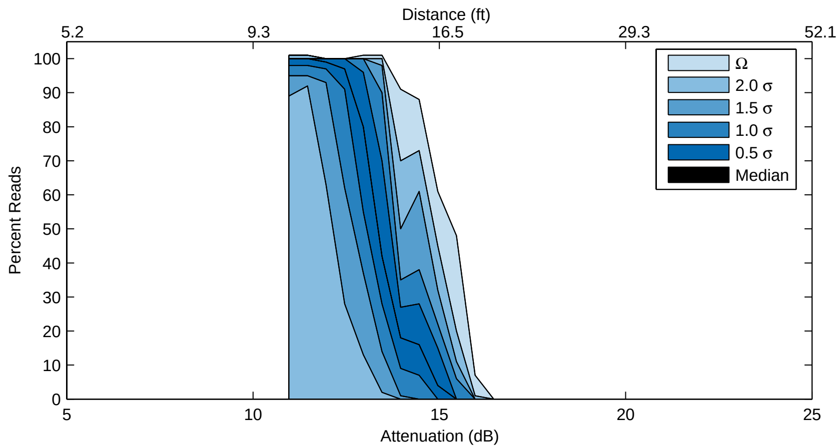


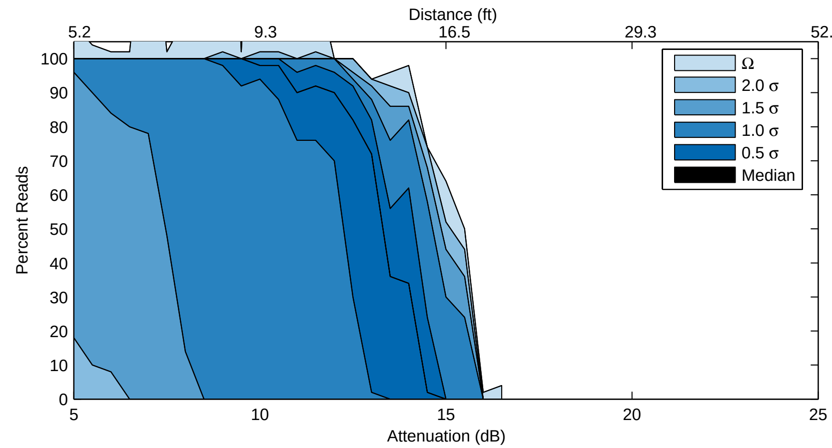
Variation of Tag Performance

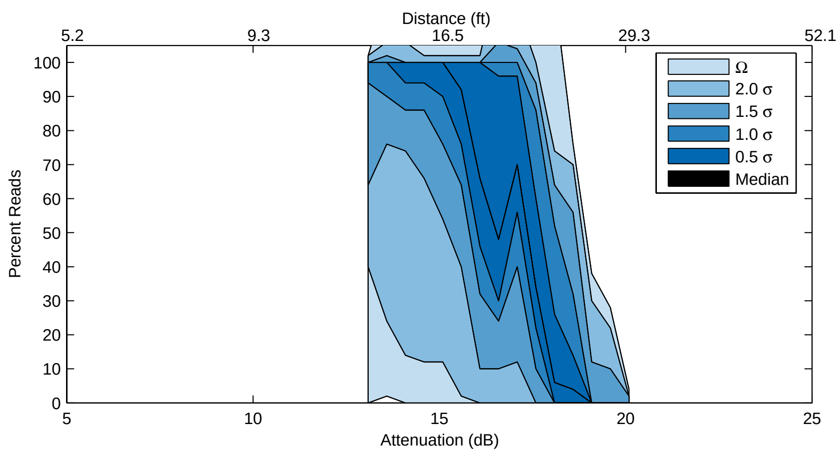
- Tags vary in performance
  - Model to model
  - Tag to tag
- Experiment: Characterize performance of 100 tags of each model and compare.
- Within a tag model, classify tags by:

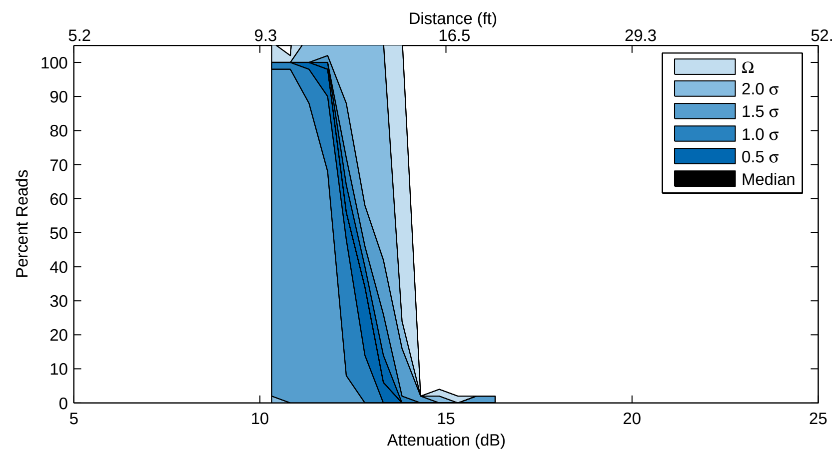
median	.5σ	σ	1.5σ	σ2	Ω
black	dark blue	.	.	.	lightest blue
50%	31-69%	16-84%	7-93%	2-98%	0-100%
1 tag	38%	68%	86%	96%	100%

Four Tag Models (preliminary)

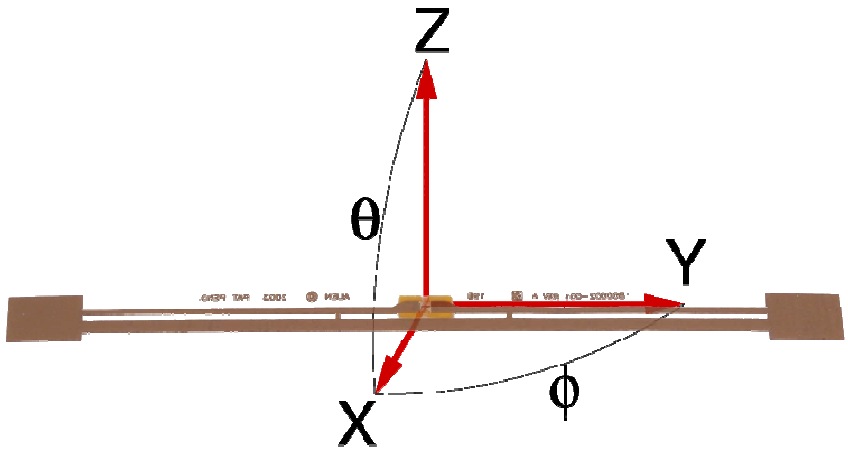








Angles and Axes



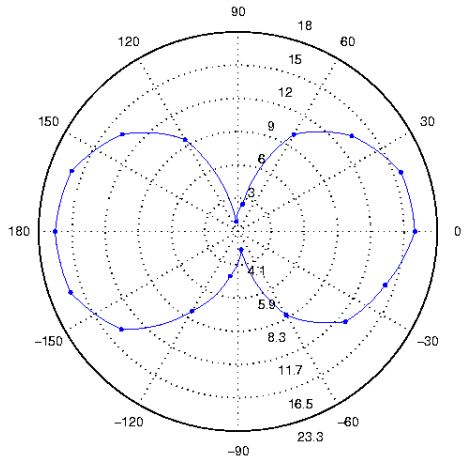
Rotation along the X-Y axes: φ

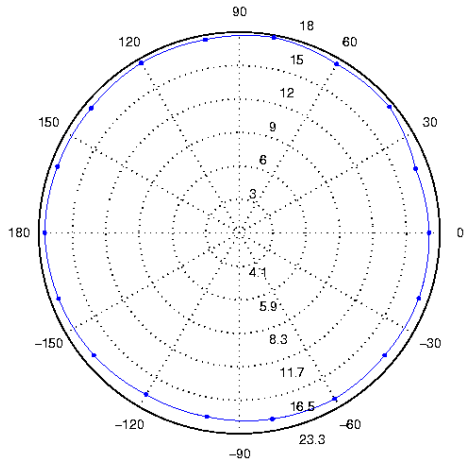
Rotation along the X-Z axes: θ

Rotation along the Y-Z axes: twisting

- Shouldn't matter with circularly polarized antennas, but our experience shows it does.

A “Dipole” Design

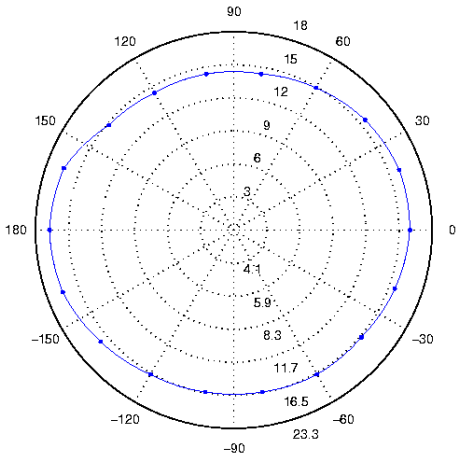


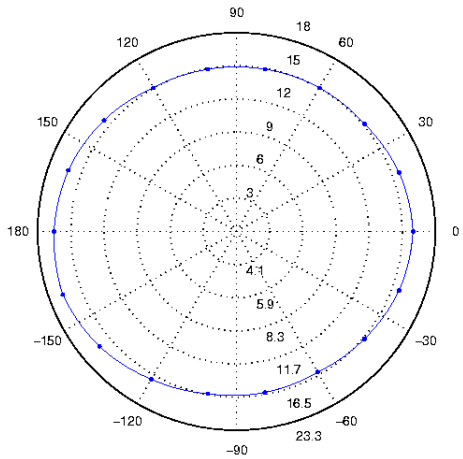


Characteristic of all long, narrow tags

- Read range nearly zero when looking at ends of dipole
- Read performance nearly uniform along other axis

A “Dual Dipole” Design



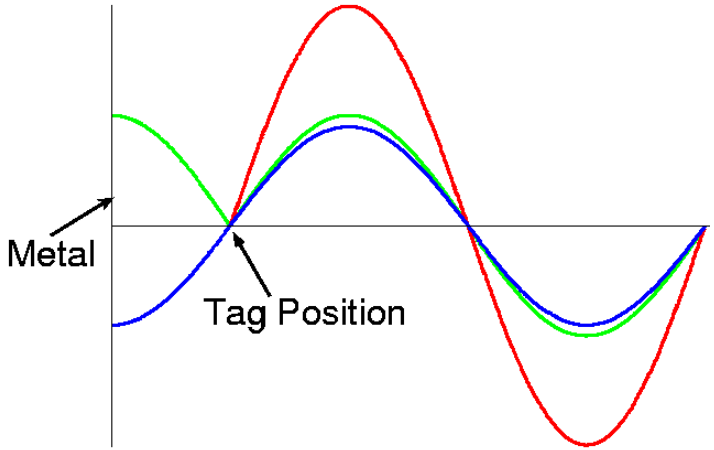


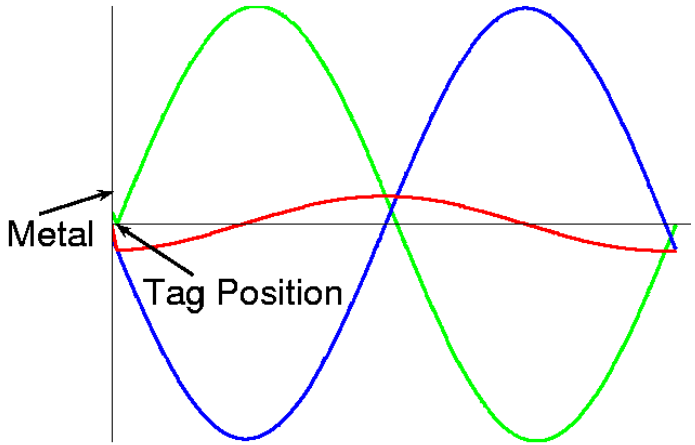
Characteristic of large, square/triangle

- Read performance nearly uniform in all orientations

Constructive/Destructive Interference

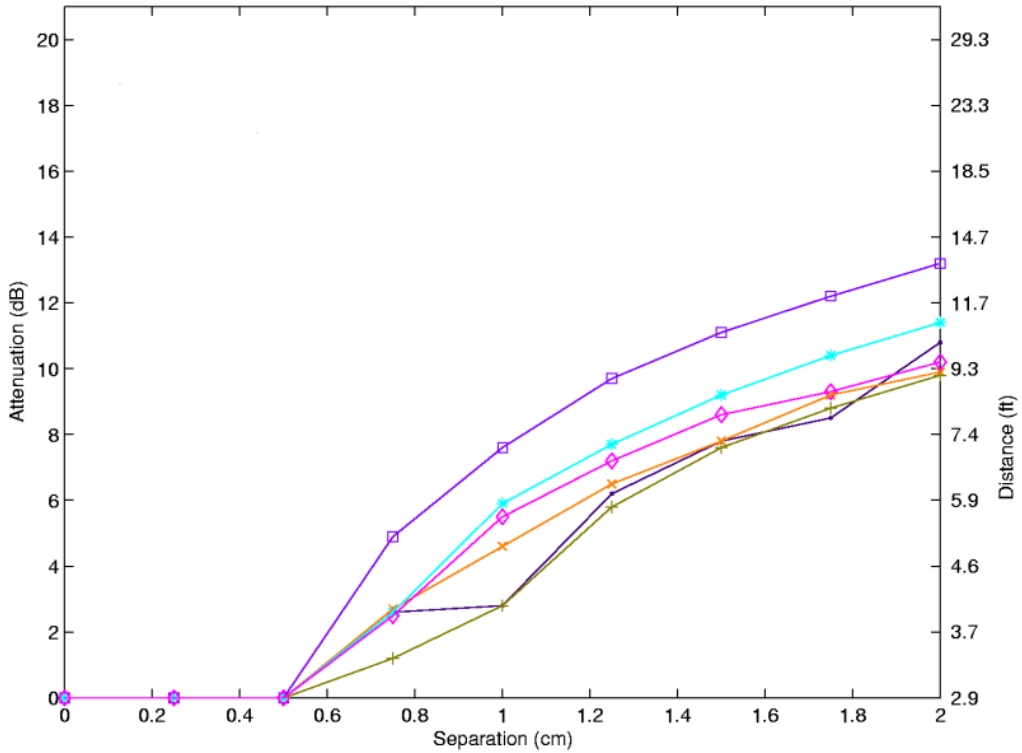
- Metal reflects RF 180 degrees out of phase
  - Can enhance RF signal (constructive)
  - Can degrade RF signal (destructive)
- Legend:
  - Green – transmitted
  - Blue – reflected
  - Red – superposition (received)





Performance of Class 1 Tags near Metal

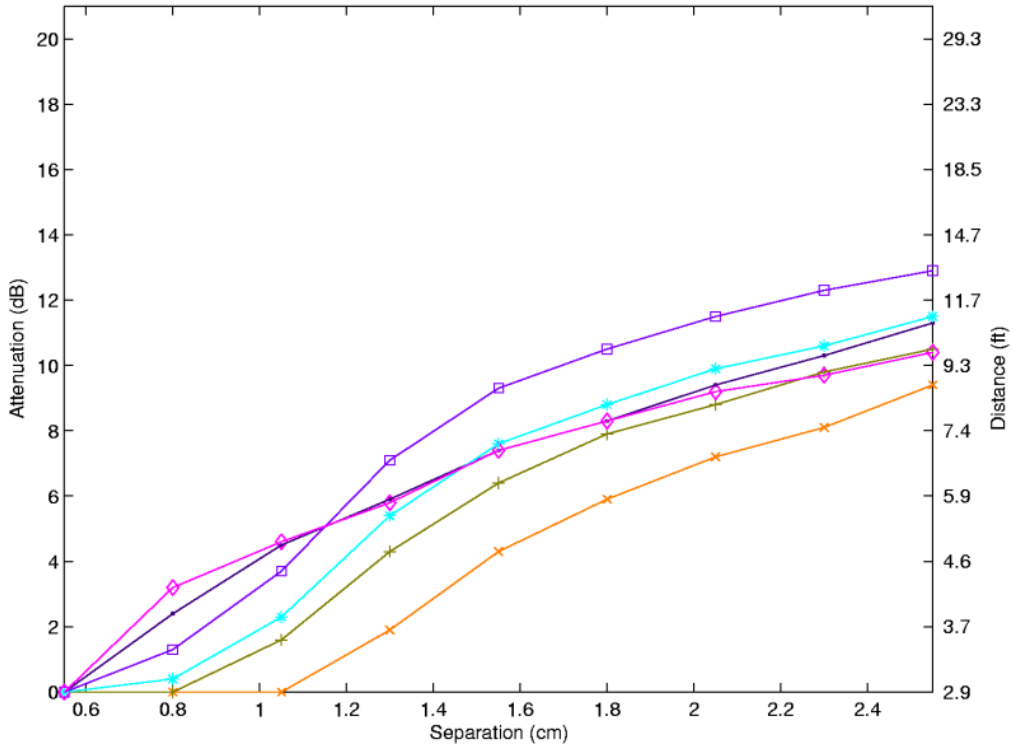
- In destructive interference region
  - most difficult
- Best tag:
  - 150% more efficient than worst
  - 60% further distance



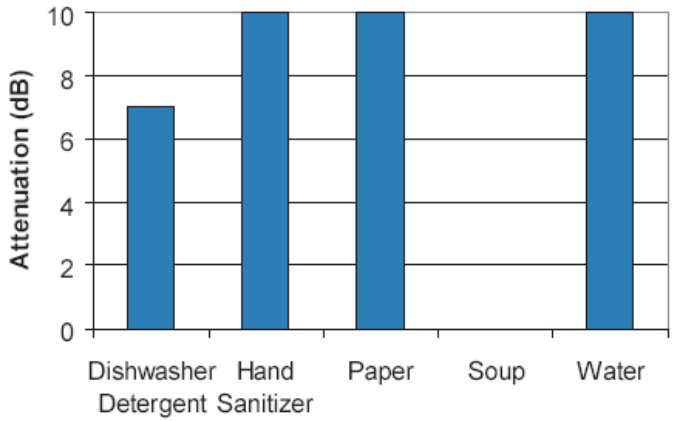
Performance of Class 1 Tags near Water

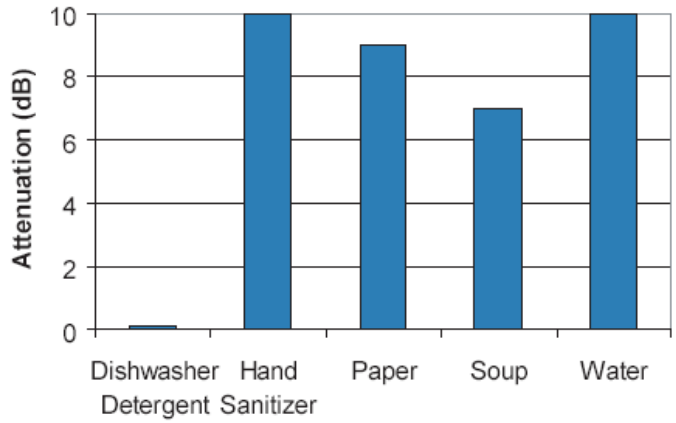
Differences readily apparent

- Pink best close, but shallow slope
- Purple good close, but best further
- Best tag:
  - 150% more efficient than worst
  - 60% further distance



Tags on Conveyor





- Least scientific test conducted
  - 2400 measurements taken
- Interesting experiment — objective is to get as far away from metal/water as possible
- Size of tag plays large role
  - Smaller tags get bigger air gaps

Summary from First Report

- Not all tags are created equal
- Consider neighboring materials
  - Metal and water can substantially degrade performance (get as far away as possible)
  - Interaction between packaging and tag can cause unexpected problems
- Be cautious not to over-generalize results

Future Projects

- Durability
  - ESD
  - Shock
- Open Pilot
- OpenRFID
  - Hardware and software platforms

How Can I Participate

- Buy a report
- Partnerships
  - Advisory roll
  - Special access
  - Perform testing on your site, involve your people
- Special projects
- Donations (money, equipment, time, etc.)

Conclusions

- RFID is tricky — no “cookbook” solutions
  - Information that we’re gathering is valuable, but only part of the puzzle
- Don’t believe the hype
- What you don’t know can hurt you